NASA Facts

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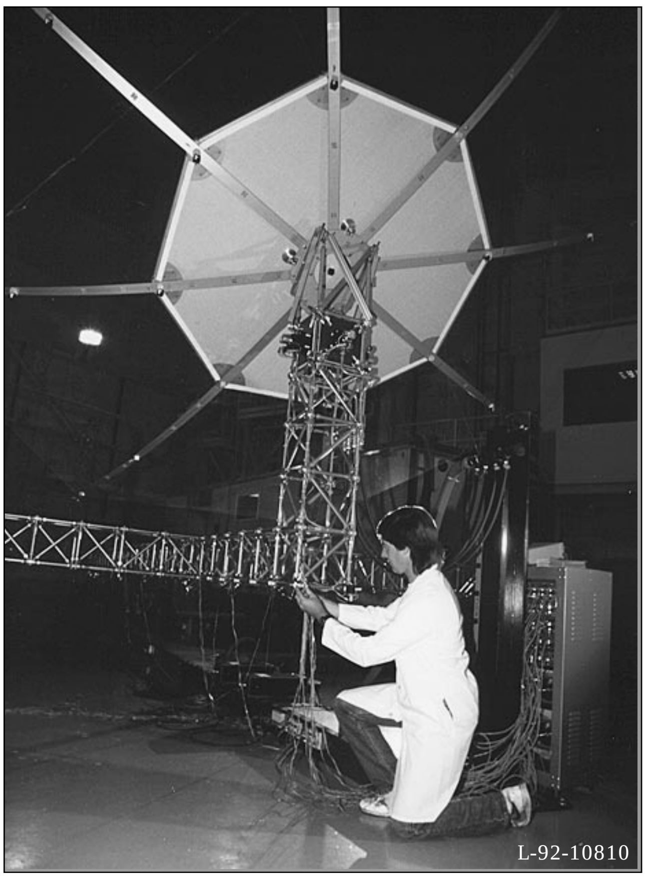
NASA works to control spacecraft motions

Making flexible satellites stable and affordable



NASA technician David Kessler connects a thruster to the back of a satellite dish on a space structure model at Langley. The structure, 52-feet long, is part of a research program dedicated to overcoming unwanted vibrations and jitter of flexible space structures.

As more and more things are attached to spacecraft and as some of the spacecraft themselves get larger, they are developing a bad case of the jitters. These jitters — small motions that move from one end of the spacecraft to the other — can interfere with observations of our Earth and with studies of deep space.

NASA is part of a joint NASA/U.S. Air Force-led effort to understand and control these motions. The multi-year program is called the Controls-Structures Integration (CSI) program and is supported by government, industry and universities.

Langley tests will help spacecraft designers

In tests at NASA's Langley Research Center, Hampton, Va., the benefits of considering a spacecraft's control system and how it relates to the structure at the earliest design stages were dramatic. One benefit: A smarter control system that used significantly less energy. The control system typically operates a series of actuators or tiny jets fired for short bursts when an onboard sensor detects spacecraft jitter.

At Langley, researchers have hung a 52-foot (15.6m) model from a high ceiling to simulate a space structure in the weightlessness of Earth orbit. The crane-like structure is vibrated at one end — as if, for instance, an external scanning mirror on the spacecraft had just been activated — causing a very small jitter to ripple through the structure. The responses of this jitter at various locations on the spacecraft are measured and fed into a computer model for analysis. The process is then repeated under slightly different conditions. Present testing is looking at computer control of precision pointing hardware for telescopes and other applications and the integration of active structures. Active structures use advanced materials that stretch or contract when an electrical voltage is applied. A future phase of the Langley ground tests is scheduled to begin in the mid-1990's and will focus on controlling a model of an advanced CSI-designed version of the first low-orbiting satellite in the U.S. Earth Observing System (EOS).

Need driven by increasing size and flexibility of spacecraft

The results from Langley and other tests will help spacecraft designers determine the best weight and stiffness for future spacecraft — strong enough to limit unwanted movements yet light enough to be affordable.

The need is driven by the increasing size and flexibility of spacecraft and by the increasing sensitivity of their instruments. Scientists and other users of spacecraft data demand a stable platform for precise measurements or observations. At the same time, future spacecraft — with antennas large enough to see intense rain cells less than one mile across — could be as large as two or three football fields in length.

Teamwork marks program approach

Complementary CSI work is ongoing at NASA's Jet Propulsion Laboratory, Pasadena, Calif., NASA's Marshall Space Flight Center, Huntsville, Ala. and the Air Force's Phillips Laboratory at Edwards, Calif. and Albuquerque, New Mexico.

Additionally, a joint NASA/Department of Defense guest investigator program currently includes Boeing Aerospace & Electronics, Seattle, Wash., Harris Corporation, Melbourne, Fla., Martin Marietta Space Systems, Denver, Colo, Massachusetts Institute of Technology, Cambridge, Mass. and Texas A&M University, College Station, Texas.

In-space flight experiments will provide final validation of CSI technology. NASA Langley is funding MIT's development of the Middeck Active Control Experiment, a 5-foot (1.5-m), highly-flexible, multibody platform. The flight article is stored in the Shuttle Orbiter's middeck lockers and is assembled by the crew for zero-gravity dynamic testing. It is scheduled to fly in mid-1994.

Applications from Earth observations to astronomy

To demonstrate key technologies, the NASA CSI program focuses on three mission classes. The first includes platforms with flexible antennas and vibration control systems. Antennas from approximately 50 feet (15 m) to approximately 260 feet (80 m) or more could be used for Earth observation, radiometry, radio astronomy and higher performance communications spacecraft. Earth observing technology is increasing in importance because of public concern for pollution monitoring, global warming and ozone depletion.

Another class of missions covers advanced optical systems with microprecision control. Such space observatories could detect objects at the outer edges of the universe. A third mission class includes astrophysics experiments and high energy sensors. These precision instruments may lead to an explanation of the "missing mass" of the universe.

Aside from the future applications of this technology, there are several near-term challenges where the work can be applied to today's problems. For example, an engineering team from NASA Marshall and NASA Goddard Space Flight Center, Greenbelt, Md., in collaboration with Lockheed Missiles and Space Company, Sunnyvale, Calif., recently applied CSI technology to reduce pointing jitter on the Hubble Space Telescope. As with Hubble, any satellite with solar arrays and other flexible structures is susceptible to movement caused by "thermal snap," when a cold spacecraft suddenly emerges into direct sunlight after leaving the dark side of the planet.

Another near-term application of CSI technology focuses on the damping behavior of the Space Shuttle robotic arm. The arm often vibrates for long periods after use — with valuable time wasted waiting for the device to settle. Astronauts are presently evaluating this application of CSI technology in the Shuttle Engineering Simulator at the Johnson Space Center, Houston, Texas. Results of these tests will be used to determine the need for an in-space demonstration aboard the Space Shuttle.